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By-Twelker, Paul A.
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This paper outlines the Teaching Research approach to designing instructional simulation systems, a three-phase approach which involves (1) determining what to teach, (2) determining how best it might be taught, and (3) validating the system. An effort is made to "expose the vital decision points" in each of the 13 steps listed: (1) Define the instructional problem, (2) Describe the operational educational system, (3) Relate the operational system to the problem, (4) Specify objectives in behavioral terms, (5) Generate criterion measures, (6) Determine appropriateness of simulation, (7) Determine type of simulation required (interpersonal-ascendent simulation, machine or media-ascendent simulation, or nonsimulation games), (8) Develop specifications for simulation experience, (9) Develop simulation system prototype, (10) Try out prototype system, (11) Modify the prototype system, (12) Conduct field trial, (13) Make further modifications to the system deemed appropriate from field trial evidence. Included in the Step 6 outline are a list of situations in which simulation may be a useful, cost-justified method and a list of arguments against simulation. A table for use in Step 7 presents the relative advantages (in terms of 18 instructional factors) of each of three types of simulation techniques. Four references are listed. (JS)

Designing Simulation Systems

Paul A. Twelker
Teaching Research
Oregon State System of Higher Education

The purpose of this paper is to outline the approach of designing instructional simulation systems developed at Teaching Research. Detailed step-by-step explanations are beyond the scope of the present paper. They are available elsewhere (Crawford and Twelker, 1969). However, the thirteen phases of simulation design will be summarized, and an effort will be made to expose the vital decision points that confront the designer as he develops simulation experiences.

A Rationale for the Design of Instructional Simulation Systems

In designing an instructional simulation system, or any instructional system, for that matter, it is useful to think of a gap -- the difference between the learner, where he is before instruction and after instruction. Before instruction, we assume that he lacks some knowledges or skills necessary to perform satisfactorily in an operational situation. After instruction, we assume that he possesses these skills. Our problem is to specify the learning conditions necessary to bridge the gap between the learner's initial repertoire and final criterion repertoire.

How best are these instructional conditions specified? Are there instructional methods effective in all kinds of learning activities? To be certain, there are some general rules of thumb that seem to hold in a variety of conditions, such as the provision for proper feedback, active participation, spaced practice, and so forth. Yet, it is clear that these guides do not lead us far enough down the road of instructional specification to be of much help at this stage in our technology. Too many decisions must be made in the course of specifying instructional conditions that cannot be answered by examining past research, theory, or intuition. Decisions must be made in the best manner possible, and this requirement has in large part prompted the approach to be discussed below. This approach may be summarized as: (1) determining what shall be taught; (2) determining how best it might be taught; (3) validating the system.

The word "system" used above has a special connotation and points up the fact that a simulation experience should not be conceived of as an isolated experience taken out of the context of the overall instruction. The term, "simulation system" infers that the simulation component of the system is accompanied by other "non-simulation" components. The components describe what curricular

units precede, accompany, and follow the actual simulation exercise. Also, the word "system" denotes an interrelated set of components ranging from media and manuals to student learning materials.

Specific Steps in Designing Instructional Simulation Systems[1]

Step 1. Define instructional problem

Before one can improve instruction, he must step back and examine in broad terms what preceded his decision to develop a new instructional system, and what might follow if his intentions were realized. What condition has motivated his tampering with the status quo- why does he believe that intervention can improve the conditions? What is the problem? What are the proposed solutions to the problem? What information led to the definition of this problem? In addition to defining the problem, the designer should make a thorough analysis of the context in which the system is to operate.

Step 2. Describe the operational educational system

Why analyze the operational system? What is suitable for one set of objectives taught in a given environment may not be effective for the same objectives taught in a different environment that has different constraints placed upon it. For example, an excellent instructional system that is designed for teaching one child at a time may not be appropriate for teaching two or more simultaneously. The constraints of the system in which the designer expects to operate must be described. In analyzing the operational system, the designer must define:

Learners for whom the system is being designed (target group),

Number of personnel available to him on the project (man power),

Supporting equipment (machines),

Personnel scheduling, available curriculum material, description of course limits, and developmental time (procedures and materials),

Administrative limits, (management),

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[1] The thirteen steps are summarized in Figure 1.

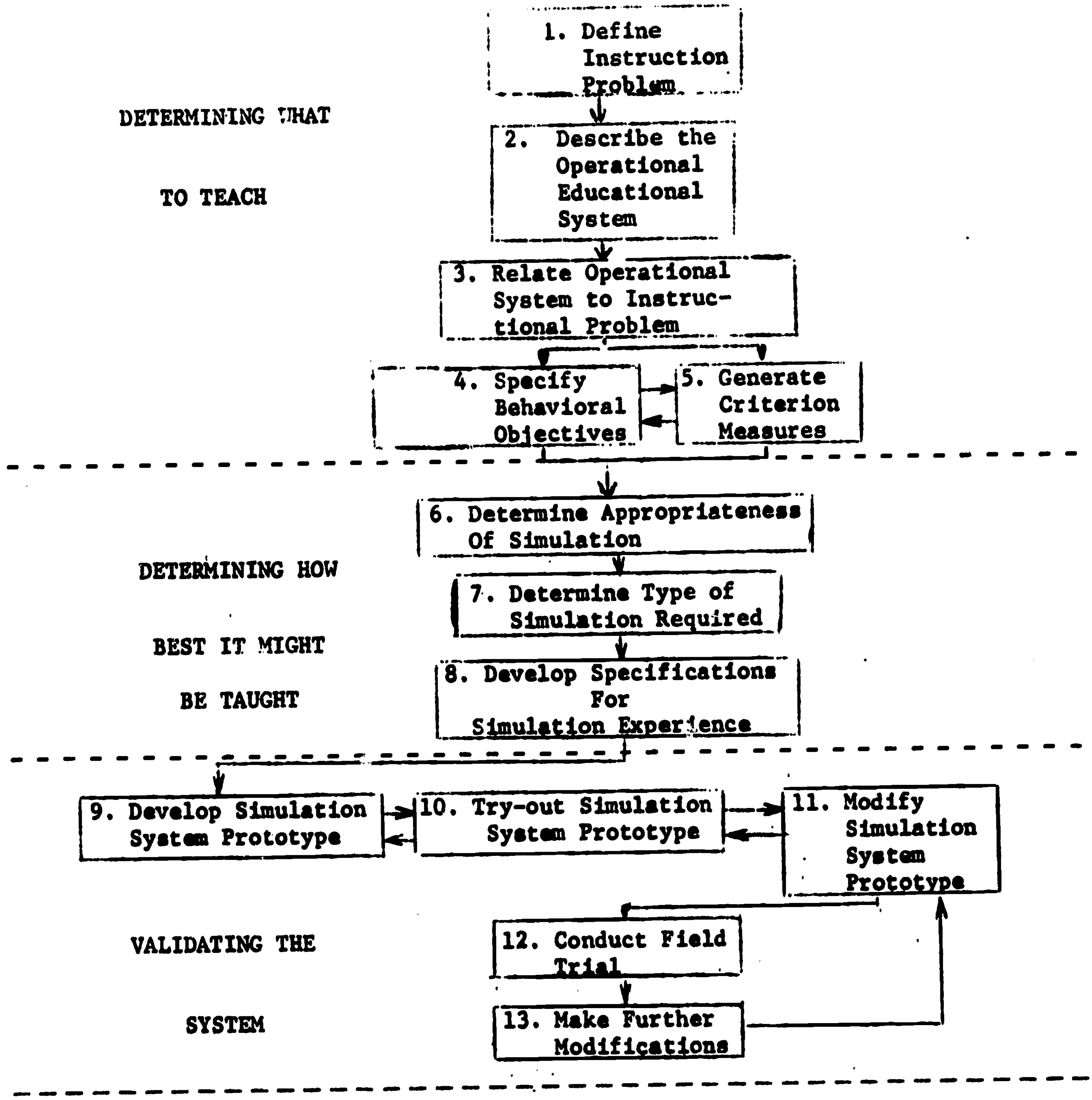

Figure 1.
Steps in the Design of an Instructional Simulation System

Facilities (setting),

Money available for the ongoing system and money available for developing the new system (funds),

Instructional philosophy or orientation that guides the system as well as the designer (educational orientation).

In summary, the designer should examine any element that he feels helps him to define the problem more clearly and to propose appropriate solutions.

Step 3. Relate the operational system to the problem

The inputs identified above must be related to each other. It makes little sense to think of an educational problem in isolation to the context in which it is found. This relating of the initially identified problem with the system may cause the designer to redefine or restructure the problem. In some cases the designer will face the choice of delimiting his interests and choosing certain aspects of the problems he has identified. This is based on the assumption that the more one knows about the system, the more problems will be perceived.

Step 4. Specify objectives in behavioral terms

There has been some confusion regarding the "hows" or specifying behavioral objectives, whether they be enabling or terminal. Enabling objectives state in precise terms the specific knowledge/skills the student must learn in order to arrive at the terminal performance. Terminal objectives state in precise terms the behavior that the learner is expected to exhibit after instruction. Where do objectives come from? Typically, the designer might begin by examining the unique key words, phrases, concepts, definitions, and rules that he frequently uses in the instructional unit. He looks at their natural sequence. That is, he analyzes a set of key concepts or definitions to see which are requisite for learning other key ideas. He constructs a hierarchy of principles that tell him in what order these principles should be taught. Basically, this analysis is used in the context of specifying what to teach, and requires the designer to choose some performance (that may or may not end up to be a terminal performance) and successively asking the following question: "What kind of capability would an individual have to possess if he were able to perform this objective successfully, were we to give him only instructions to do?"

Where else does the designer look for objectives? He may check his final exams he has been giving, and attempt to assess the degree to which they really tap the skills desired

on the part of the student. He sees if there are more life-like settings that could be developed that might more closely approximate the real skill that is being taught and tested. Perhaps a case study, filmed situation, or taped dialogue would be a better assessment tool. The designer actually generates specifications for some of these tests. Then he asks the question, "Does that behavior satisfy me that the knowledge/skills have been taught?" The designer infers knowledge from performance.

One other point should be emphasized. Educational objectives may be thought of as either stated (intentional), or unstated (unintentional). Stated objectives are those determined by the designer to be important and relevent to his problem. Unstated objectives are those which are not verbalized by the designer, but which may be just as appropriate as those stated. In designing instructional simulation experiences, where vivid experience is the keynote rather than reported experience, it is especially important that unstated objectives are considered. For example, extreme competition in a simulation game may produce the desired stated objectives, but at the risk of promoting dishonesty, thus not fulfilling an unstated objective regarding proper interpersonal behavior.

Step 5. Generate criterion measures

Simultaneous with determining behavioral objectives is the development of criterion measures. These take two forms: (1) terminal performance measures, and (2) enabling performance measures. The measures for assessing terminal performance determine whether or not the stated outcome behaviors were acquired by the learner as a result of the instructional experience. The measures for assessing enabling performance determine whether or not prerequisite behavior, necessary for adequate performance on the terminal objectives, have been acquired during instruction. Again, the designer should pay some attention to generating measurement insurements for unstated objectives.

Step 6. Determine appropriateness of simulation

Simulation has several advantages over more conventional forms of instruction, although cost may be more. Seven possibilities in which simulation may offer a useful and cost - justifiable alternative are:

1. Simulations are appropriate when objectives emphasize emotional or attitudinal outcomes;

2. Simulations integrate affective and cognitive behavior;

3. Simulations initiate sustained learner activity and motivation;

4. When the objective is to represent a social or man-machine system in such a way that the learner must interact with it, the system will react to the learner's moves, and the learner can discover the effects of alternative decisions, simulation is useful;

5. Simulation, in which a high degree of commitment may be introduced, is useful when emphasis is upon incorporation of the behavior desired within the personal domain of the learner;

6. Simulations provide an interest - sustaining mode that is particularly useful for exercising behavior, particularly under a variety of contexts;

7. Simulation is a most powerful means of placing a learner into a desired "set" or "perceptual frame" to sensitize and direct him.

On the other hand, there are some arguments against the use of simulation:

1. Simulation is not so efficient when it comes to the acquisition of cognitive knowledge as measured by typical tests;

2. Simulation may cost more than conventional types of instruction;

3. More information can be presented in less time by more traditional means of instruction;

4. Simulations, particularly the learning game variety, often introduce considerable changes in classroom noise level, physical movement, and teacher role that are highly suspect to some instructors;

5. Simulations are often difficult to evaluate because of the human processes that are modeled.

Step 7. Determine type of simulation required

If a decision has been reached to consider the use of simulation, the next set of decisions relate to the kind, or the attributes, of the simulation to be designed. The three major possibilities are: interpersonal-ascendent simulation, machine/media-ascendent simulation, and non-simulation games.

Interpersonal-ascendent simulation refers to the role playing and decision making, player-interacting simulations as typically found in such games as Consumer, Crisis, and Manchester. Interactions between learners carry a large share of the instructional burden.

Machine-or media-ascendent simulations are characterized by the instructional burden being carried largely by media (for example, slide-tapes, films, programed instruction, computer output, and so forth.) Examples include flight trainers, systems trainers such as weapons systems simulators used by the military for submarine crew training, computer-based business games and classroom simulation (Twelker, 1967; Cruickshank, et. al. 1967).

The third category of non -simulation games, is included, despite its non-sequiter label, largely because of the number of learning games that are being developed that do not simulate a model of reality. Such game includes the Nova game: Wff'n'Proof, On-sets, and Equations. These games certainly bring some of the advantages of simulation games to instruction, but do not simulate any social or physical system. Yet, they do provide involvement on the part of the learner in the application of concepts and principles drawn from formal disciplines.

Table 1 presents the advantages of each type of simulation technique. It should be noted that the advantages listed are relative advantages and do not preclude the possibility of one or another type of simulation being adequate in any given situation.

Step 8. Develop specifications for simulation experience

A common error that novice simulation designers make is to assume that the simulation exercise represents reality per se. They fail to realize that the simulation is not based on reality directly, but on a model or theory of reality. In other words, the model is a representation that is in some way removed from reality. It might be appropriate to say that a simulation will only be as good as the model on which it is based. The model is usually stated in general terms and includes many variables that may be deleted or altered in the simulation. Thus, the simulation is a representation of the model, but not an exact image. Changes have occurred. It behooves the simulation designer to construct or use the best fitting model he can so that he subsequently builds a fair chance of representing the relevent aspects of reality adequately. If the model is not a good representation of reality, that is, it distorts reality or omits relevant aspects of reality, and the simulation designer does not recognize this, the simulation has little chance of

Factor	Type of Technique: Interpersonal Ascendent Simulation	Maching/Media Ascendent Simulation	Non-simulation Game
1. Control (reproducibility) desired	Questionable	Good	Difficult
2. Control (planned variation) desired	Questionable	Very Good	Good
3. Input must be machine mediated e.g., visual stimuli required	Not easily adopted	Appropriate	Not easily adopted
4. Psychomotor and perceptual learning involved	Questionable	Very Good	Questionable
5. Learners posses low entry skills & limited response repertories that prevent an interpersonal-ascendent simulation from functioning	Limited value	Useful	Questionable
6. Teacher control over class required	Not so good	Very good	Fair
7. Simple and inexpensive technique desired	Good	Not easily done	Very good
8. Interaction between learners required	Very good	Possible but costly	Good
9. Burden of simulation experience on learner required	Good	Possible	Possible
10. Model that emphasizes human interaction involved	Very good	Not easily done	Questionable
11. Individual differences must be considered but expensive to implement	Good	Not easily done	Good
12. Feedback must be easily designed into system	Good	Sometimes costly and difficult	Good
13. Feedback must come from peers	Good	Difficult	Good
14. Easy development process required	Sometimes difficult	Sometimes difficult	Very good
15. Insertion into curriculum must be easy	Sometimes difficult	Sometimes difficult	Very good
16. Must be generally acceptable	Sometimes difficult	Good	Very good
17. Few learners involved	Limited	Good	Very good
18. Learning objectives congruent or identical to standard course objectives	Limited	Good	Very good

Table 1 - Advantages of Each Type of Simulation

instructing learners in the appropriate behavior. The relationship between reality, the model, and the simulation are graphically presented in Figure 2.

Step 9. Develop simulation system prototype

At this point, a good share of the work of simulation system design has been accomplished, and the "fun" of building the system begins. The main task is that of translating instructional "blue prints" into prototype. The more complete and thought out the blueprints, the faster and easier the development.

Step 10. Tryout simulation system prototype

An empirical tryout of this system is mandatory. The tryout is limited in nature. If possible small groups of learners, or even one learner at a time if appropriate, are taken through the system by the designer. Close monitoring of the learners is undertaken. Analysis of the system is not limited to this. Learners may be requested to verbalize problems with the materials, and suggest alternate strategies. It should be noted that the limited tryout of a system such as a simulation game may look quite different than a tryout of the media-ascendent simulation. Video taping of simulation game prototypes is an extremely effective way to capture activity for later analysis with a select group of learners sitting with the designers. Sometimes, a simulation may be tried out on colleagues before using learners that represent the target group so that responsible criticism may be obtained.

Step 11. Modify the simulation system prototype

Three major decisions are made during this step: (1) If the system seems appropriate for obtaining the stated objectives, how can it be improved? (2) If the system does not seem to be appropriate for obtaining the stated objectives, how can it be changed? (3) If the system does not seem appropriate for obtaining the stated objectives, should it be discarded in favor of a non-simulation system?

Step 12. Conduct field trial

The field trial serves to aid the designer in determining if his newly developed system is capable of standing by itself, that is, being used in the field under operational conditions by members of target population. Designers often neglect this crucial step, reasoning that "since I was successful in using the system, everyone else can use it now". The safest thing a designer could do is subject his system to a trial under field conditions. When this is done, the designer may wish to collect data concerning the stated outcomes as well as the unstated outcomes. In some cases, the designer might consider securing the services of a third-part evaluation team to conduct the field trial.

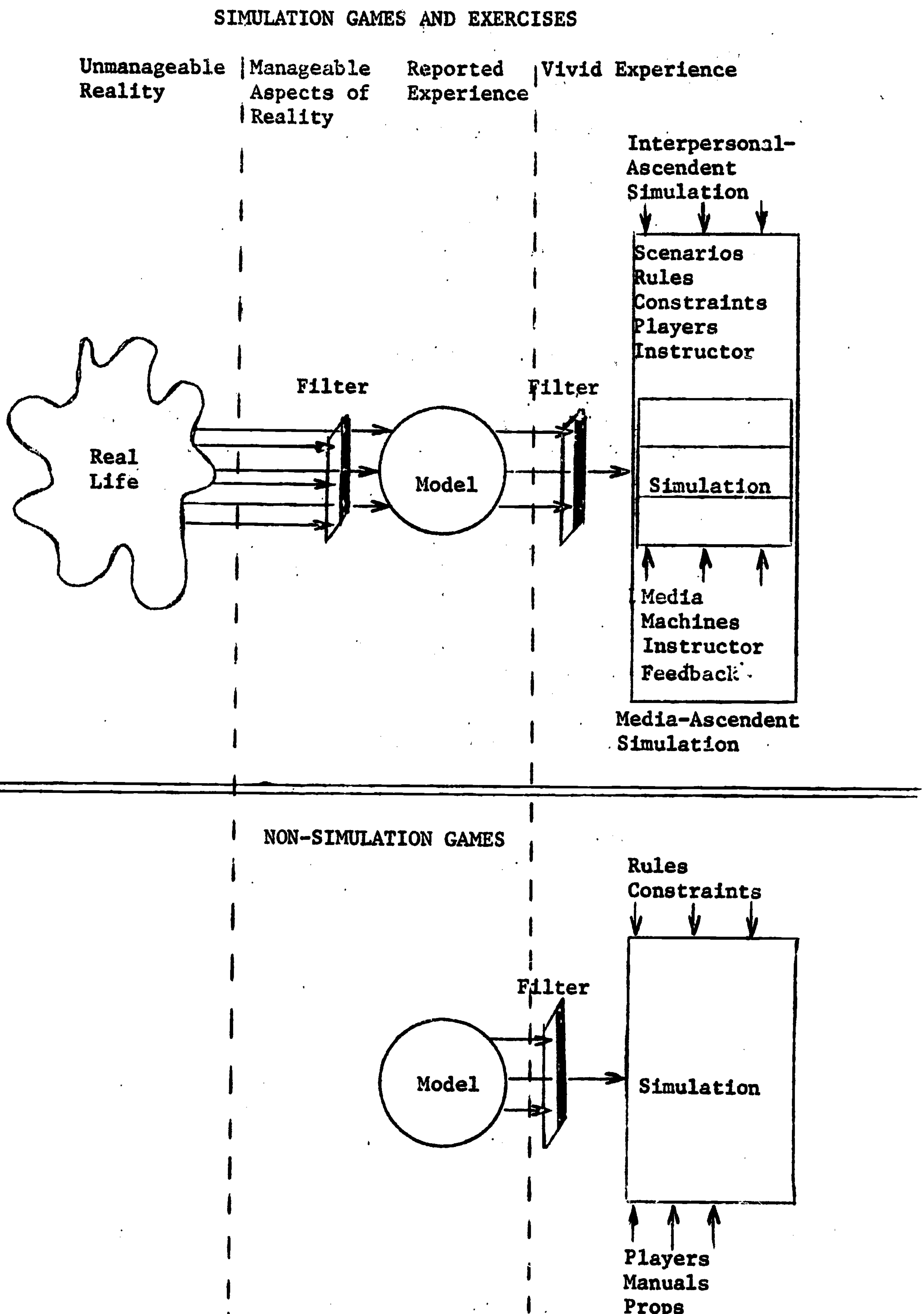

Figure 2.
Graphical relationship between
reality, models, and simulations

Step 11. Make further modifications to the system deemed appropriate from field trial evidence

When this point is reached, it is hoped that few "bugs" are found in the system as detected during the field trial. If the previous steps have been executed in excellent manner, the field trial will indicate improvement, not major changes. At this time, the designer may also begin investigating ways to disseminate his system.

A Final Word

Sarane Boocock and E. O. Schild state in their book on Simulation Games that "simulation design is not only not a science, it is hardly a craft, but rather an 'art' in the sense that we have no explicit rules to transmit." (Boocock and Schild, 1968, p. 266) Others have made essentially the same statement of media-ascendent simulation. This position can not be argued. Further, the guidelines offered above certainly are one step in the right direction as meaningful research directions may be specified in the context of the development of simulation exercises.

References

Boocock, Sarane S., & Schild, E. O. (Eds.) Simulation Games in Learning. Beverley Hills, California: Sage Pub., Inc, 1968.

Crawford, Jack, & Twelker, Paul A. The Design of Instructional Simulation Systems. In Paul A. Twelker (Ed.) Instructional Simulation: A Research Development and Dissemination Activity. Monmouth, Oregon: Teaching Research Division, Oregon State System of Higher Education, February, 1969. (U.S. Office of Education Final Report, Project No. 7-I-045).

Cruickshank, Donald R., Broadbent, Frank W. & Bubb, Roy L. Teaching Problems Laboratory. Chicago: Science Research Associates, Inc., 1967.

Twelker, Paul A. Classroom simulation and teacher preparation. The School Review, 1967, 75, 197-204.